DOCUMENT RESUME

ED 306 087 SE 050 469

AUTHOR Spector, Barbara S.; Gibson, Charles W.
TITLE Middle School Students' Perceptions of Factors Facilitating Learning Science.
PUB DATE 89
NOTE 22p.; Paper presented at the Annual Meeting of the National Association for Research in Science Teaching (62nd, San Francisco, CA, March 30-April 1, 1989).
PUB TYPE Speeches/Conference Papers (150) -- Reports - Research/Technical (143)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS *Cognitive Processes; Cognitive Style; Curriculum Design; Intermediate Grades; Junior High Schools; Learning Processes; Learning Strategies; *Middle Schools; *Science and Society; Science Instruction; *Science Programs; *Secondary School Science; *Student Attitudes; Teacher Behavior; Technology; Theory Practice Relationship

ABSTRACT

The purpose of this study was to explore middle school students' perceptions of what factors facilitated their learning of science. Between 50 and 60 high-achieving middle school students were in residence on the University of South Florida campus for 12 consecutive days of study in the "World of Water" program. There were two sessions per summer for the past five years totaling 572 participants. Eight specially trained teachers were in residence with the students. Between 50 and 70 experts from the university, government, and business/industry interacted with the students each year in an innovative science/technology/society program. A written assignment toward the close of the program had students reflect on their experiences in residence at the university comparing learning in the program to learning in their schools. These essays were the base for this study. Document review, participant observation, and open-ended interviews were used to gather and triangulate data in five phases. A theoretical model suggesting ways to combine a variety of approaches to curricula, instructional designs, delivery modes, and teachers' behaviors that could help middle school teachers build those factors that facilitated the learning of science into school science courses was generated. (MVL)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

ED306087

National Association for Research in Science Teaching
March, 1989 Conference
San Francisco, California

MIDDLE SCHOOL STUDENTS' PERCEPTIONS OF FACTORS FACILITATING LEARNING SCIENCE

U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

☒ This document has been reproduced as received from the person or organization originating it.

☐ Minor changes have been made to improve reproduction quality.

• Points of view or opinions stated in this document do not necessarily represent official OERI position or policy.

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY

Barbara Spector

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

by

Barbara S. Spector
College of Education EDU308G
University of South Florida
Tampa, Florida 33620

and

Charles W. Gibson
Science Department
Largo Senior High School
410 Missouri Avenue
Largo, Florida 34640

SE 050 469

ABSTRACT

MIDDLE SCHOOL STUDENTS' PERCEPTIONS OF FACTORS FACILITATING LEARNING SCIENCE

The purpose of this study was to explore middle school students' perceptions of what factors facilitated their learning of science.

Florida's Educational Reform Act of 1983 funded programs providing the states' precollege students with summer learning opportunities in science, mathematics, and computers. The programs were intended to encourage the development of creative approaches to the teaching of these disciplines.

Under this program, between 50 and 60 high achieving middle school students were in residence on the University of South Florida campus for 12 consecutive days of study in the World of Water program. There were two sessions per summer for the past five years totaling 572 participants.

Eight specially trained teachers were in residence with the students. Between 50 and 70 experts from the university, government, and business/industry interacted with the students each year in an innovative science/technology/society program.

An assignment toward the close of the program had students reflect on their experiences in residence at the university and write an essay comparing learning in the World of Water program to learning in their schools. These essays were the base for this study.

This was a qualitative study using a discursive approach to emergent design generating grounded theory. Document review, participant observation, and open ended interviews were used to gather and triangulate data in five phases.

In phase one, essays were put in groups by year, numbered, and read in chronological order by yearly groups beginning with those generated in 1984. Students' statements identifying things which were of importance to them were extracted. Potential relationships among the statements were sought to identify categories and generate hypotheses.

In phase two, the researchers were participant observers in the two 1988 program sessions (totaling 112 students) looking for behavioral evidence for what students said was occurring and what was important to them.

In phase three, the 1988 students and individual staff members were interviewed during the program using open-ended questions derived from and reflecting the categories and emerging hypotheses.

In phase four, open-ended group interviews of staff were conducted during the staff debriefing week at the close of the 1988 second session.

In phase five, the staff and the researchers explored implications of the findings for enhancing post baccalaureate education of middle school science teachers.

Some of the factors middle school students in this study perceived facilitated their learning science follow:

1. experiencing the situtations about which they were learning
2. having live presentations by professional experts
3. doing hands-on activities
4. being active learners
5. using inductive reasoning to generate new knowledge
6. exploring transdisciplinary approaches to problem solving
7. having adult mentors
8. interacting with peers and adults
9. establishing networks
10. having close personal friends who shared their interest in learning
11. trusting the individuals in their learning environment including adults and students
12. experiencing a sense of self reliance.

The preceding information was used to generate a series of hypotheses which were woven together into a theoretical model suggesting ways to combine a variety of approaches to curricula, instructional designs, delivery modes, and teachers' behaviors that could help middle school teachers build those factors that students said facilitated their learning of science into school science courses.

MIDDLE SCHOOL STUDENTS' PERCEPTIONS OF FACTORS FACILITATING LEARNING SCIENCE

PURPOSE

The purpose of this study was to explore middle school students' perceptions of what factors facilitated their learning of science.

THE SETTING

Florida's Educational Reform Act of 1983 began the funding of programs providing the states' precollege students with summer learning opportunities in science, mathematics, and computers. The programs were intended to encourage the development of creative approaches to the teaching of these disciplines.

Under this funding, the model for the World of Water, a residential transdisciplinary program for middle school students, was pilot tested with 120 students on a university campus in North Miami during the summer of 1984. It was refined, and tested again in 1985 with a new group of 120 students at the same site. In 1986, the model was exported to its current site in central Florida on the Tampa campus of the University of South Florida. There were two sessions per summer for the past 5 years.

With this model, between 50 and 60 high achieving middle school students were immersed in 12 consecutive days of study during each session. Eight specially trained teachers were in residence with the students. Changes in staff during the 5 years resulted in a total of 22 different teachers having been in residence. Between 50 and 70 experts from the university and local government and business/industry interacted with the students each year in an innovative science/technology/society program.

The curriculum was organized within a conceptual framework of research using cooperative learning strategies and an open ended transdisciplinary approach to activity design. Student activities focused on the physical and chemical properties of water and the way each property influences water's affect on the world in which we live. Sample activities in which students engaged included: investigations at the laboratory bench to determine surface tension, density, osmolarity, etc., of salt and fresh water; snorkeling in the gulf and the bay to get an underwater perspective of marine life in its natural environment; canoeing on the Hillsborough river to ascertain the impact of humans on fragile river environments; sailing in the bay to learn physics principles; investigating The Living Seas Pavillion at EPCOT to compare human made environments to natural environments; and conducting soil filtration investigations in the laboratory, exploring sink holes, and investigating Hooker's Point Waste Water Treatment Plant to understand the need for and ways to supplement natural processes that keep an adequate supply of fresh water available. While a traditional pretest and posttest were given to fulfill grant requirements, the significant evaluation of the application

of higher order thinking skills and content acquisition was done through creative drama, poetry, enacting role plays grappling with environmental concerns, various type writings, and team game formats. Other relevant and salient features of the program are evident in the data provided by the students which is reported in a later section.

An assignment toward the close of the program had students reflect on their experiences in residence at the university and write an essay comparing learning in the World of Water program to learning in their schools. These essays were the base for this study.

SUBJECTS

The subjects were the 572 middle school students who participated in the program since its inception. They were all highly successful within their schools having won many awards in science and/or mathematics and having engaged in numerous science, mathematics and computer extra-curricular events. Entry into the program was extremely competitive e.g., in 1988 there were 1550 applications for 112 openings. Students came from 59 of the state's 67 counties spanning rural, suburban, and urban areas, public and private schools, and representing the ethnic and racial mix in the state.

METHOD

Qualitative methods involving a discursive approach (Smith, 1982) to emergent design generating grounded theory (Glaser and Strauss, 1967) were used for this study. In the methods used, the phenomenological data gathered during the study directed the design of each step of the study as it evolved. The categories, themes, hypotheses, and subsequent theory that emerged were "grounded" (had their foundation) in the data themselves. The emergent theory was used to support and/or add to existing theory.

This study was conducted by two researchers. One was new to the program and became part of the milieu specifically to conduct research. The second was the architect of the program and serves as its director. Data were collected from three different sources and triangulated in five phases. The sources were 1) document review of the 572 essays produced by students over five years, 2) participant observation of the 112 students in the two 1988 program sessions, and 3) interviews with the 1988 staff.

In phase 1, essays were put in groups by year, numbered, and read in chronological order beginning with those generated in 1984. Students' statements identifying things which were of importance to them were extracted. Segments of the data were constantly compared within yearly groups and between yearly groups. Specific examples given by students to make a point were compared with previous examples in the same and different groups. Comparisons were made between diverse and similar evidence. Common underlying messages or themes that tied different statements to each other were used to categorize the data.

All the essays were read a second time seeking additional statements which supported or refuted the categories. Potential relationships among the

categories were sought and hypotheses generated.

In phase 2, the researchers were participant observers looking for behavioral evidence for what students said was occurring and what was important to them.

In phase 3, students and individual staff members were interviewed during the 1988 program to obtain further evidence confirming what the students said was occurring and what was important to them. Open-ended questions derived from and reflecting the categories, themes, and emerging hypotheses guided the interviews. This phase included a check on reliability in which interpretations were summarized and presented to current students and staff members for verification. Several subjects' perceptions were compared to each other in order to identify likenesses and differences in their responses.

In phase 4, open-ended group interviews with staff were conducted during the staff debriefing week at the close of the second session. The data and the interpretations were presented to the staff as a further check on reliability. Validity and relevance were checked by asking the staff if the categories fit and worked; whether they were clearly indicated by the data; and whether they explained, predicted, or interpreted anything of significance. After the model of the factors the students perceived facilitated their learning emerged from the data, the researchers addressed the question of whether the students' perceptions of what facilitated their learning science had any basis in existing theory.

In phase 5, the staff and the researchers explored implications of the findings for enhancing the post baccalaureate education of middle school science teachers.

DATA AND ANALYSIS

Characteristics of Schools

The students' responses from all five years' essays comparing learning in schools to learning in the World of Water (WOW) were consistent even though there were differences in the sites, staffing, and specific activities. A composite view of schooling from the 572 highly successful middle school students, herein, indicated that their schooling was characterized by sitting down, being quiet, reading books, listening to lectures, and answering book and teacher posed questions. They typically described their school learning experiences this way:

> "At school you listen to the teacher all day" (David).
>
> "At school they throw a book at you: 'Here, study'. Test on pages 114-139 tomorrow" (Christine).
>
> "In school we get lectured and told to answer the questions in our book" (Craig).
>
> "School is like a place where you are sent to everyday to be taught by reading books" (Michelle).

Characteristics of the World of Water Program

When contrasting learning in their schools to learning in WOW, students expressed consensus that learning in WOW was:

" ... unlike school in every way" (Norma).

" ... so much fun that I didn't even know I had learned something until after it happened" (Sheryl).

" ... where you can actually touch, see, hear, smell, and taste the things you only see in books in school" (Yasser).

"At school we take one step at a time, at WOW it seems like one great leap" (Bachar).

They characterized learning in WOW as:

1. **experiencing the situations about which they were learning**
2. **having live presentations by professional experts**
3. **doing hands-on activities**
4. **being active learners**
5. **using inductive reasoning to generate new knowledge**
6. **exploring transdisciplinary approaches to problem solving**
7. **having adult mentors**
8. **interacting with peers and adults**
9. **establishing networks**
10. **having close personal friends who shared their interest in learning**
11. **trusting the individuals in their learning environment including adults and students**
12. **experiencing a sense of self reliance.**

The preceding 12 factors are what the students identified as facilitating their learning of science in WOW. The perceived effectiveness of the combination of these factors in facilitating learning science was evident in comments such as:

"The teaching methods incorporated into WOW are unusual and actually make it easier and more exciting to learn" (Allison).

"Learning in WOW is better than learning in school" (Jeanne).

"Wow has doubled what I learned in one year at school" (Hun).

"I learned more here than I learned in six months at school" (Pat).

"I found WOW the best overall learning experience I have ever had" (Clyde).

Participant observation and interviews with the students and staff in the 1988 program confirmed the factors above and provided behavioral evidence to support what the students said was occurring and what was important to them. The factors were grouped. The relationships within the groupings and supporting quotations from the students' essays are discussed below. The emergent theoretical model tying all the factors together follows.

Experiential Learning (Factors 1-4)

The multifaceted experiential learning structure of the program enabled students to be actively engaged throughout the learning process. Overt components of the structure included face to face interaction with guest experts, hands-on activities, and first hand experiences with real world situations about which they were learning. This was in sharp contrast to these students' perceptions of learning in schools. They made it clear that being active learners facilitated their learning more than the perceived passive learning of books and teacher lectures.

> "I feel that the teaching method of hands-on experiences is much more educational than working from a textbook" (Mohammed).
>
> "In the real world experience is the key to success. Hearing about subjects doesn't do nearly as much good for you in the future as doing them" (Walid).
>
> "Here you see what you are talking about and get to do more hands-on labs" (Don).

The large variety of activities combined with continuous interaction with residential staff who served as mentors (academic coaches) facilitating learning contributed to students perceiving themselves to be totally immersed in learning throughout their waking hours.

> "WOW is unique and unlike anything I've ever experienced before. Everyone works hard here, but it is a different kind of hard work. ... Some people might call it brain work. Everyone is constantly using their brain. It seems as though their brains never rest" (Kala).
>
> "There also are more hands-on activities. It is more exciting this way. It adds a little bit of flavoring to the soup. ... You will never find a dull moment here. Everyone is constantly doing something" (Sam).
>
> "One thing that I especially appreciate is the ability to have access to a living encyclopedia set, (the residential staff and guest experts) the ability to stay ... with people who spend their entire life on one thing, biology, astronomy, physics or whatever" (Hans).
>
> "The time is used more creatively at WOW than in school. Instead of doing the same thing day in and day out they have a wide variety of activities" (Loi).
>
> "I certainly didn't expect to learn as much as I have. The hands-on exhibits and variety of subjects was interesting. Everyday I have learned something new" (Heather).
>
> "In school we learn everything verbally. At WOW you can do hands-on experiments. Some hands-on experiments are working in labs, writing or typing on a computer, going snorkeling" (Jim).

(Educators usually define "hands-on" as teaching through having students physically manipulating objects in a classroom or school laboratory setting in the pursuit of learning. The students in this study used "hands-on" to encompass the preceding educators' definition and actual participation in any activity or event.)

Students were emphatic about the fact that the experiential learning mode increased their (A) motivation, (B) rate of learning, (C) depth of comprehension, and (D) meaningful learning.

(A) motivation

"hands-on experience makes me want to learn instead of being forced to learn" (James).

"The strange thing about WOW's education styles is the fact that they are fun. ... This style of learning makes students want to learn" (Sheryl).

(B) rate of learning

"I have learned about ten times faster than I could even fathom doing in school" (Hoon).

"WOW is much more interesting than school and the learning process is much more efficient and is faster" (Jorge).

"I feel that I have learned a great amount of new and interesting things that I would not have learned at such a rate or in such a short time" (Ronnie).

"Learning here has been so much different from not only school but any other camp like settings that it is incredible. We can complete much more in the same amount of time. I can honestly say that I have learned more in one week of WOW than in a month and a half at school" (Erin).

(C) depth of comprehension

"Hands-on learning kind of lets what we learn actually sink in" (Kenneth).

(D) meaningful learning

"I think the fact that we get to actually experience things instead of getting them out of books helps to impress ideas with more meaning" (Noel).

"You go places and see what they're talking about so you can get a better understanding of the subject" (Kurt).

"The thing that makes WOW so special is that I have not just learned about certain things, but the reasons why I need to know about them. I have learned the importance of many things" (Ira).

Inductive Transdisciplinary Problem Solving (Factors 5 and 6)

The program's conceptual framework of research solving real world problems necessitates that teachers (residential staff) assume the role of learning mediator/facilitator. This role is dependent upon the modeling of the full range of research paradigms used within the scientific enterprise and questioning strategies guiding students in the use of inductive reasoning to generate new knowledge. Real world problems, having their foundation in science, technology, and society interaction, are inherently transdisciplinary (integrate information from many disciplines into concepts to reveal the whole and require application of skills from different disciplines).

Students recognized the complexity and transdisciplinary nature of real world problems they explored.

"...the activities at WOW are a lot more involved than the ones in school" (Emma).

They also noted that the program structure made connections among disciplines and integrated skills from many different disciplines that students traditionally studied separately in schools.

"WOW lets you imagine in such activities as play writing, art, computers, and writing skills" (Leslie).

"We have a schedule of events for every day including either laboratory studies and experiments, computer programming, drama skills, swimming, mathematics or the most important part which is the hands-on experiences "(Bonita).

The students noted an appreciation for the fact that the residential staff modeled inquiry techniques.

"WOW allows learning to flourish. Our counselors set the example while being teachers and guides; ... They are knowledgable in their special fields and are willing to experiment with us to find out what they do not know" (Akio).

"... (Staff are) unique persons who learn and teach almost as much as we do!" (Lynn).

Students also recognized that deliberate questioning strategies were used by staff to guide inductive reasoning and encourage them to evolve their own concepts and theories.

"When you ask a question, often times a counselor would ask you questions about the problem. This may seem strange because it sounds as though they are trying to avoid the question, but in actuality, by answering their questions you can develop an understanding of the problem and can answer your own question. I feel that this method is good because you get more out of the discussion than just a yes or no answer" (Mark).

"If someone asks a question in school, the teacher gives them a long detailed answer which leaves no room for further questions. Here they do leave room for further questions. The answer is short and brief. They encourage you to ask questions. It is a way of expanding your knowledge about certain subjects"(Nicholas).

Further, students clearly valued collecting their own data, analyzing their own data, and drawing their own conclusions.

"...if it were a lab in (a school) science class, it would be very dull. The instructor informs you of everything, including the results of the experiment. This takes all the fun out of it" (Vishnu).

"This way we get to make our own observations instead of reading about other people's observations" (Philip).

"We are taught to 'teach ourselves' by doing first hand experiments in the labs and seeing and understanding the results" (Dirk).

"WOW's atmosphere encourages questioning, reasoning, and experimenting. Every lesson taught has been understood by the ... (students) because during each lesson there were activities making them think, question and reason." (Richard).

Having opportunities to inquire and induce concepts from their own experiences helped students develop a view of the scientific enterprise as an active living human endeavor using multiple approaches to disciplined inquiry instead of only as an accrued body of facts to be memorized. This had positive affects on students.

"WOW has shown me a new way of looking at science. All of the things we have learned all tie together in a way that I have never noticed before. This system emphasizes questions, many of them. It is a whole different form of research from school and it works alot better. ... (emergent design research) allows you to solve more involved questions than simple closed experiments could" (Shirley).

The Affective Domain (Factors 7-12)

Students universally focused on the affective dimension of the World of Water program.

"WOW is one of the few places in the world that allows one to learn and feel in the same environment. The problem with our school system today is that one is not taught or allowed to feel. In the classroom, learning and feeling are not recognizable together. They are strangers" (Nada).

Four aspects of the affect that students addressed were (A) fun while learning, (B) the emotional bonding with people who care and share, (C) experiencing self-reliance (independence), and (D) the impact of the psychological climate on learning.

(A) Fun while learning

The popular slogan, "no pain - no gain", which seems to pervade our society's model of growth in both athletics and intellectual pursuits including in middle schools, was refuted by the data from students in this program. They indicated that learning rigorous science (and other disciplines) was fun at WOW and inferred that there was a positive relationship between the amount of learning and the amount of fun they had:

"WOW truly expresses that learning can be fun" (Robert).

"WOW combines fun with work" (Scott).

"Here we learn by experimenting and having fun" (Roberta).

"It (WOW) teaches in a new kind of way, really makes learning fun" (Sabrina).

"Every event we do here is a learning experience, but in a way fun. I like it because you are doing this to have fun but you learn at the same time" (Omar).

"But WOW was much more than just fun. The activities combined learning and work with fun. Making WOW much more interesting and challenging to all who participated" (Rob).

"The strange thing about WOW's education styles is the fact that they are fun. Actually learning has been so much fun that I didn't even know I had learned something until after it had happened. This style of learning makes students want to learn" (Sheryl).

"I think school should be more like WOW by presenting more challenges and doing more hands-on activities. The World of Water is an exciting, fun, and interesting way to learn" (Tari).

"WOW has a variety of learning experiences that makes learning fun" (Sharon).

"The teaching methods are unique because they use a mixture of fun and education" (Javier).

"Science at WOW is really interesting as well as being very fun" (Eddie).

(B) The emotional bonding with people who share and care

Congruent with what is known about the nature of the transescent, the most powerful finding in this study was the overwhelming importance of bonding to these transescents and the need for them to be in an environment which they perceived as safe. A perception of psychological safety emerged from believing they were able to trust the people in their environment. They spoke of trusting the individuals in their WOW learning environment including adults and students and having close personal friends at WOW who shared their interest in learning. This bonding resulted in the formation of human networks highly valued by the students. Bonding emerged as the single most significant influence affecting their learning of science in the World of Water program.

There appeared to be a chain of affective events leading to the formation of networks among students which began with individual students bonding to their assigned roommates (2), extending to their suitemates (4), family groups (10), activity groups (20), and the total group (60). Simultaneously, students bonded to staff members following a similar developmental sequence. Thus, they created an emotional support network which made them feel safe:

"Everyone became my friend" (Sheretta).

"I will never forget the friends I've made here. They gave me so many things. First, they comforted me when I felt down. They made me feel welcome in a place I knew nothing about. They inspired new dreams and hopes. I plan to follow through with them in the future" (Tim).

"The unity of WOW is unique. It is all a relationship of people who are bound by a common likeness. This likeness is knowledge" (Jose).

"All of us came from all over Florida to learn and these people who were alot like me liked to learn about science and math" (Tomiko).

"...WOW is extraordinary in that you get to meet other students like yourself from other

parts of the state" (Valerie).

"I had to compromise with other people besides my assigned buddy . For this reason I have drawn closer to the other young people at camp. This will allow me to have friends all over the state" (William).

"...staff is nice, friendly, kind and caring" (Carl).

"(Staff) here at WOW are very nice and understanding, and are super at being a counselor and a friend at the same time" (Maureen).

Bonding at WOW was discussed in the context of the social isolation these students felt in their schools because of their intellectual accomplishments; the pressure to get A's and maintain their images as always being right; and their desire for close relationships with peers.

"There is a unique feeling of togetherness within the family groups and activity groups. Your family leader is like a second father or mother. You really get to know people in your group and they really get to know you. In (a school) class, if you are smart you are considered a square or a nerd. After a while, you can really get sick of that. You won't see that at WOW. The people share some of the same qualities you have. There is a challenge to learning once again (Joanne).

Although these students were as successful as any students could be in schools, it was clear that they entered WOW with a behavioral norm used in schools: They were unwilling to venture to be wrong as part of the learning process in a group. It appeared that (1) the staff's nonjudgemental behaviors and the modeling of inquiry, and (2) the degree of bonding students experienced with each other and the staff made them feel safe, setting off a chain of psychological events resulting in increased learning. Students felt free to speculate, which lead to innovative ways of seeing things and inventing ideas. They had the courage to take intellectual risks by testing these ideas with others. Their lack of defensiveness emerged as a willingness to display their intellectual prowess and creativity and to modify ideas using input from others which resulted in increased learning.

"One of the beneficial aspects of WOW's program is the relaxed atmosphere it provides. In the past two weeks never have I experienced any pressure to be the best due to the surrounding environment. I always know that whether I'm right or wrong I have tried, succeeded and learned from doing so. The fact that we are not judged on our progress during WOW is a relief. Knowing that the only person we have to please is the most important person, ourselves" (Brian).

"I can truthfully say that I have not heard the word "wrong" out of any counselor's mouth this whole twelve days at WOW! (John).

"(WOW).actually gives me the "courage" not to be afraid to ask questions, to wonder, to imagine" (Allan).

"...(There is) opportunity to be able to ask questions no matter how insignificant..." (Sharal).

"I did not feel hesitant to ask questions or take notes because I was surrounded by ...(students) willing to do the same thing. If anyone has a question the answer is always easily accessible" (Benjamin).

Students used their emotional support networks for technical support as well.

"First of all, it (WOW) has taught me the meaning of mutualistic symbiosis. At camp everyone learned from each other. We get information from each other, copy it, and return the originals. No one was harmed in the exchange, yet both gained a great deal." (Wen).

(C) Experiencing self reliance (independence)

A characteristic of the transescent is the search for self identity. Experiencing self-reliance was perceived by students as independence, a key factor in their search. Being trusted was perceived as giving them independence.

"The one thing that I think is most important is independence. School gives no independence at all. WOW gives everyone the trust of independence as if we were adults" (Sue).

In WOW, students perceived they were given responsibility for their own academic learning and responsiblity for each other, for their relationships with people, and for the group's success.

"Independence. Responsibility. They are often associated. At WOW they are one" (Mert).

"Responsibility and compromise were everyday values we learned through the buddy system. This system helped us learn how to be responsible not for something but someone" (Betty).

"When learning the responsibilities of independence comes a time to strengthen the ability to compromise. After three days of standing at the side of my nonnegotiable buddy, I soon began to understand the importance of learning the ability to compromise" (Jeff).

"I will be more responsible and respectful and easier to get along with. This is because while we are here we are expected to think for ourselves and make our own decisions" (Chuck).

"All our lives have been with someone making our decisions for us and if it was a bad decision we were not blamed for it. Now we have to make our decisions ourselves. If it was a bad decision, we would have to live with the consequences" (Mario).

"The people here at WOW all taught me that you should be your own person, express your own ideas, thoughts, and opinions." (Jonnie).

The self confidence which emerged from students' growing independence fostered intellectual risk taking that increased their learning.

(D) Impact of the psychological climate on learning

The affective factors students perceived pervaded the psychological environment of the World of Water program facilitated learning.

> " (we)... generate more ideas in groups" (Donna).
>
> "We became close friends and sometimes we are even like brothers and sisters. This bond makes us more comfortable during the activities and allow us to absorb more" (Kathy).
>
> " In two weeks WOW has taught me more about love, trust, and friendship than I have learned in all my twelve years" (Edda).
>
> I learned so much at WOW it is unbelievable! I believe most of this was because I understood more of what I studied, because of the atmosphere I was taught in" (Troy).

THEORETICAL MODEL (see pg. 16 & 17 for diagrams)

A theoretical model of students' perceptions of factors facilitating learning science emerged. The model consists of three major overlapping and interwoven elements: trust, learning immersion, and induction.

Trust emerges when students perceive themselves to be physically and psychologically safe. Cognizance of being surrounded by a technical and emotional support system characterized by a win/win model of human interaction with adults who assume mentoring roles and with adults and peers who have shared interests and who care about each others' well being contribute to the perception of psychological safety. Opportunities to be self-reliant and develop self-confidence further contribute to the development of trust.

Learning immersion is distinguished by students being actively engaged in the learning process through physically and psychologically experiencing the situations about which they are learning. Elements of learning immersion include experiencing multiple diverse real world situations which are inherently transdisciplinary, interacting with experts, doing hands-on activity, exploring new sites, and discussing with peers and knowledgable adults both during and subsequent to experiences.

Induction, using inductive reasoning to generate new knowledge, occurs when students engage in problem solving in a variety of real world situations. Connections and patterns emerge from the information (data) they gather in the real world situations. These experiential data lead to inducing concepts which are grounded in the data and thus in the experiences themselves. Such activities promote proficiency in problem solving.

The more trust students develop, the more willing they are to risk total immersion in an experience, the more they feel free to explore a situation, and the more willing they are to take intellectual risks. The amount of data and the usefullness of the data they acquire increases with the number of diverse situations they encounter, the amount of exploration in which they engage, and the degree to which they risk being creative. The more data they have, the more likely they are to find patterns emerging from which to induce

concepts. The more concepts they induce, the more likely they are to see connections and generate theory. Thus, concept and theory building, the essence of "doing" and learning science, are facilitated when learning situations are structured to foster trust, learning immersion, and induction.

BASIS IN EXISTING THEORY

A theoretical base for the factors that the middle school students in this study identified as those facilitating their learning of science can be found in the literature underpinning the middle school movement, in effective schools literature, in psychological literature, in psycotherapy theory, in theories of creativity, and in science/mathematics/technology/society education literature.

Sample recommendations from the existing theoretical base for the middle school movement that support and are supported by the findings in this study include but are not limited to incorporating:

- a holistic approach to teaching where teachers from different disciplines plan together (NMSA, 1982),

- active learning (The Superintendent's Middle Grades Task Force, 1987),

- instruction that is interactive and demands interdependence among students (Johnson and Johnson, 1985 and The Superintendent's Middle Grades Task Force, 1987) and

- strategies responding to the special affective needs of youngsters going through pubescence and, subsequently, struggling with identity and self confidence questions (Betkouski Barnes, Shaw, and Spector, in press).

In addition, the theoretical model emerging from this study supports and is supported by

- effective schools literature emphasizing the need to increase time on task to increase learning (Denham & Lieberman, (1980),

- psychological literature pointing out that concept formation requires an experiential background. One cannot give someone a concept. (Kiel and Kelly, 1987),

- psychotherapy theory indicating that having a trusting and accepting relationship with the therapist gives a client courage to look deep inside and feel free to explore in order to learn about one's true character (Rogers, 1980),

- theories of creativity indicating that a psychologically safe environment is a prerequisite for giving students permission to be creative. Creativity is required to recognize patterns, and see things in new ways. Thus, fostering creativity enhances "doing science" (Rogers, 1954 and Taylor, 1960, 1968), and

- current science/mathematics/technology/society education literature emphasizes the need to design instruction in which: the boundaries between traditional disciplines are blurred and connections among the disciplines are

emphasized; a holistic world view of the scientific enterprise as a human endeavor and the way it is related to students lives and their culture is presented; science/mathematics/technology/society interactions provide a context for learning the diversity and unity in the natural world (AAAS, 1989).

The emergent theoretical model in this study supports and is supported by the preceding existng theories and suggests that when educators combine and operationalize existing theories, the students themselves perceive them as factors facilitating their learning science.

However, the students in this study perceived that the behaviors implicit in the above theories and recommendations, which have existed for some time, are not usually evident in middle school science courses. The disjunction between the theoretical knowledge and practice in the human organization is not unique to middle school science or education in general. The same gap between knowledge and practice has been found in the business world (Peters, & Waterman, 1982) and seems to be inherent in human organizations in general.

IMPLICATIONS OF THIS STUDY

While the preceding theoretical model emerged from high achieving students in a residential program, it has implications for teaching science to students of varying abilities in traditional nonresidential middle schools and can serve as an aid to designing effective post baccalaureate middle school teacher education.

This model suggests that the education of middle school teachers would be enhanced by helping prospective and inservice teachers develop and implement strategies that build trust, provide immersion in learning, and address inductive reasoning. Insight to such strategies may be derived from the (A) teacher behaviors, (B) approaches to curriculum, (C) instructional design, and (D) mode of delivery engendered in the World of Water program.

REFERENCES

American Association For The Advancement Of Science (1989) Science for all Americans: Literacy goals in science, mathematics, and technology. Project 2061. Washington, D. C., American Association For The Advancement of Science

Betkouski-Barnes, M., Shaw, T., Spector, B. (in press) How science is learned by adolescents and young adults, in Spector, B. & Betkouski-Barnes, M. (Eds.) Science teaching in a changing society: Grades 6-2 (a series). Dubuque, IA: Kendall/Hunt.

Denham, C. and Lieberman, A. (Eds.) (1980) Time to learn. The national Institute of Education, U. S. Department of Education, Washington, D. C.

Glaser, B. G., Strauss, A. L. (1967) The discovery of grounded theory. Chicago, IL: Aldine Publishing Co.

Johnson, R. & Johnson, D. (1985) Student-student interaction: Ignored but powerful. Journal of Teacher Education. 36, 22-26.

Keil, F. C. and Kelly, M. H. (1987) "Developmental changes in category structure." in Harnad, S. (Ed.) Categorical perception: The groundwork of cognition. Cambridge; New York: Cambridge University press.

National Middle School Association. (1982) This we believe. Columbus OH: The National Middle School Association.

Rogers, Carl (1954) Towards a theory of creativity. ETC: A Review of General Semantics, 11, 249-260.

Rogers, Carl (1980) A way of being. Boston, Houghton Mifflin.

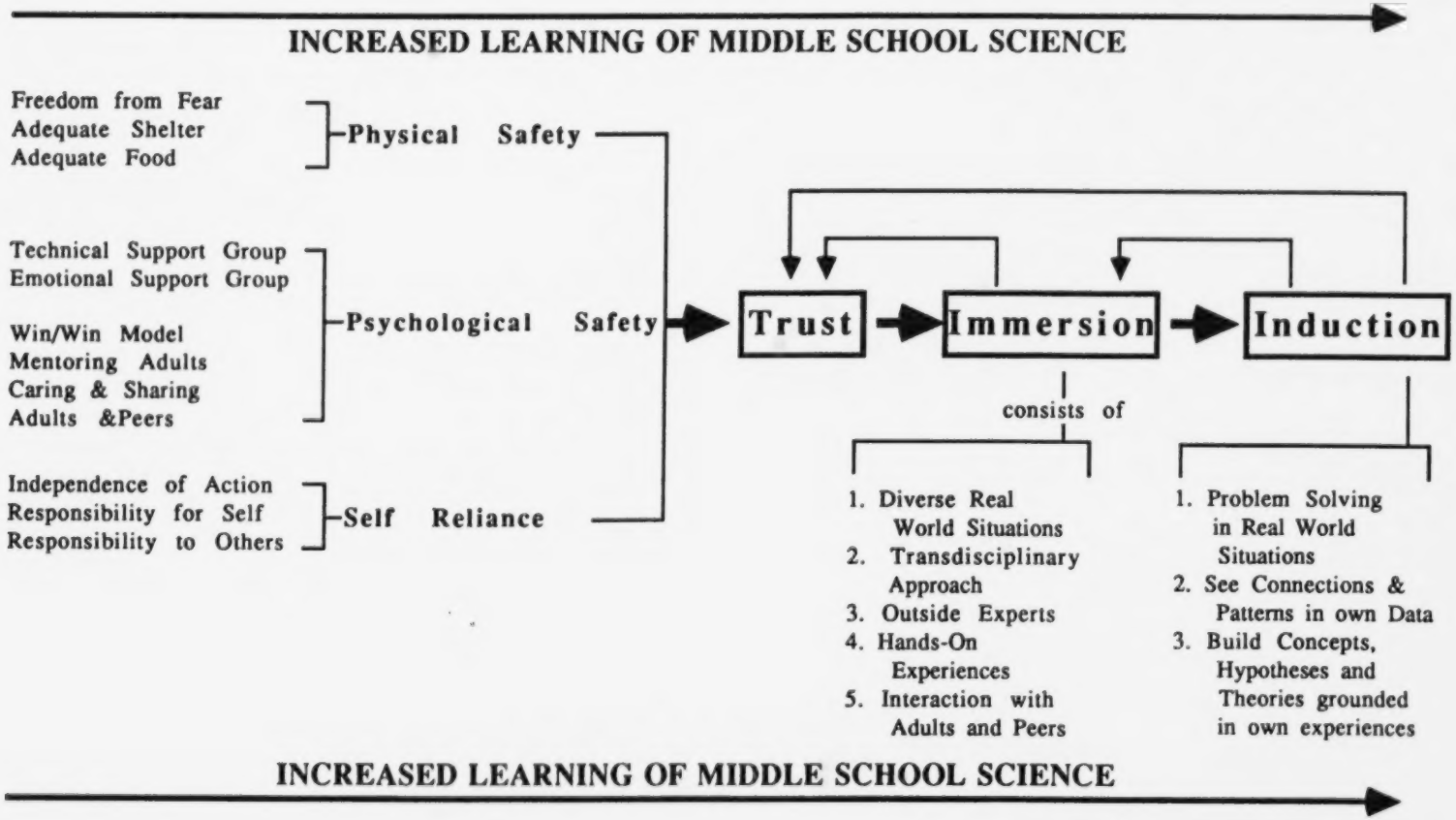
Smith, M. L. (1982) Benefits of naturalistic methods in research in science education. Journal of Research in Science Teaching. 19 (8), 627-638.

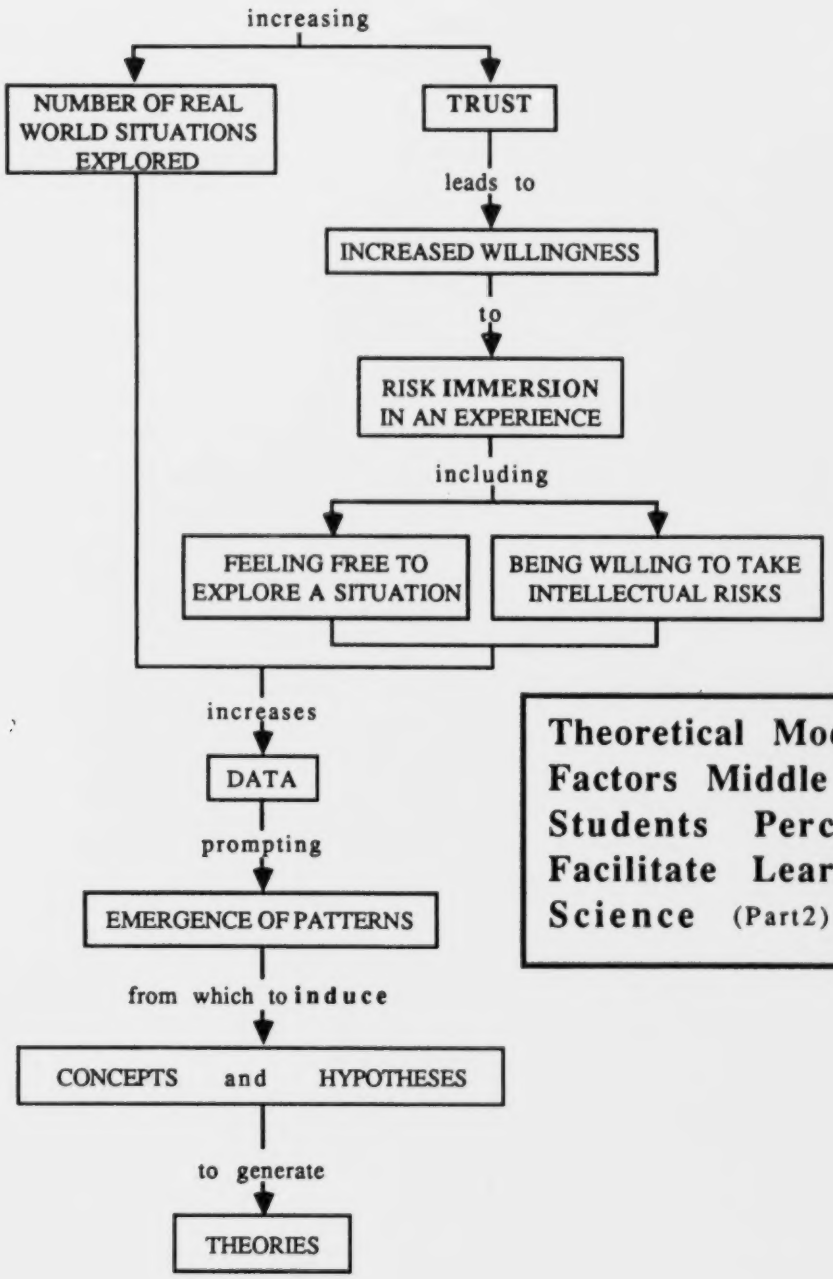
Sullivan, J. J., and Taylor, C. W. (1967) Learning and creativity with special emphasis on science. Washington, D. C. National Science Teachers Association.

Taylor, C. W. (1960) in Barkan, M. Through art to creativity; Art in the elementary school program. Boston, Allyn and Bacon.

The Superintendent's Middle Grade Task Force (1987) Caught in the middle: Educational reform for young adolescents in California schools. California, Sacramento, CA: State Department of Education.

Theoretical Model of Factors Middle School Students Perceive Facilitate Learning Science (Part 1)





Theoretical Model of Factors Middle School Students Perceive Facilitate Learning Science (Part2)